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K/EM-296

SANITIZED VERSION OF SCOPE OF PROBLEM (PLANT TOURS OR TALKS)

(SANITIZED VERSION OF CRD DOCUMENT # KP-790)

Compiled by
S. G. Thornton
Environmental Management Division
OAK RIDGE K-25 SITE
for the Health Studies Agreement

December 14, 1995

Oak Ridge K-25 Site
Oak Ridge, Tennessee 37831-7314
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the U.S. DEPARTMENT OF ENERGY
under Contract DE-AC05-84OR21400

~~SECRET~~
~~SECURITY INFORMATION~~

[redacted]

This document consists of 7 pages,
Number _ of _ copies, Series A.

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KP 790 1 A

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L-64673

SCOPE OF PROBLEM
(Plant Tours or Talks)
(Documented Work Sheet)

~~Classification changed to: C (RD)~~
~~(level and category)~~
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~~(classification guide)~~
~~1/27/94~~
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~~Sam W. Wohlfort 8/17/94~~
~~ADD signature (final reviewer) Date~~

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SCOPE OF PROBLEM

The measurement of the uranium inventories in the K-25 plant presents a multitude of problems as unique in industrial practice as the separation of isotopes by gaseous diffusion. The nature of the process, the immensity of the operation, and the character of the materials handled have resulted in problems never heard of before. The monetary and strategic value of the material has made it imperative to measure the quantities to an accuracy never before conceived for a large industrial plant handling large volumes of gases.

The plant processes several tons a day of a highly corrosive gas, uranium hexafluoride, through a series of several thousand separating units which enrich the U-235 content of the material. Each unit consists of a separating chamber containing hundreds of square feet of porous, nickel barrier; two large gas pumps; a large number of instruments; and the necessary connecting piping. Some of the factors which must be considered in order to more clearly understand the problem of inventory measurement are:

1. The process system volume is ~~nearly 800,000~~ approx. 3,537,044 cubic feet

2. A total of more than ~~20,000,000~~ 35,300,000 square feet of metal surface is exposed to the highly corrosive uranium hexafluoride

3. The plant contains ~~more than 700~~ almost 1000 miles of process piping, ranging in diameter from 3/8" to ~~18"~~ 54", and ~~700~~ 2000 miles of copper tubing

4. More than ~~150,000~~ 375,000 instruments are required to control and record the many process variables

5. The plant is operated at sub-atmospheric pressures and high temperatures

The problem of accurately measuring the pressure and temperature of a large volume of gas under changing conditions and moving at a velocity as high as 40 miles per hour is one that most engineers would call impossible. An additional complicating factor results from the fact that within each unit there are several distinct pressure and temperature zones which must be observed externally through instruments. In order to accomplish this, an almost unbelievable instrument development program has been undertaken and much progress has been made.

In addition to the measurements required in the gas system, other problems have also been found nearly impossible to solve. The material, uranium hexafluoride, is an extremely corrosive and reactive substance. It reacts with almost all chemicals, glass, water, and metals to form non-volatile solids. In order to provide against the disappearance of uranium by reaction with the plant surfaces and by reaction with moisture leaking into the plant from the atmosphere, extreme precautions have been taken such as:

(1) All metal surfaces that show high reactivity with hexafluoride have been nickel plated

(2) The entire process system is maintained at a vacuum tightness that is difficult to obtain in even small, carefully controlled, laboratory experiments. A hole, 1/64" in diameter, would be equivalent to the entire allowable inleakage for the plant

(3) All equipment is specially pre-treated to provide extra protection against corrosion, with a process similar to the pickling of metal

(4) All piping and equipment is surrounded by a blanket of air which has been treated to remove nearly all of its atmospheric moisture in order to prevent chemical reaction in case of inleakage

(5) The shaft of each gas pump must be protected by a special gas seal to prevent inleakage of moisture into the system

In spite of all these precautions, the designers of the plant feared that the disappearance of uranium on the vast area of plant surface might be so great that no enriched uranium could be produced. The actual disappearance rate has been much smaller than anticipated; however, significant quantities of uranium hexafluoride are continuously reacting with the surface area of the plant and therefore cannot be accounted for by external measurements. Since these surfaces are completely enclosed, there is no way of actually measuring the extent of the deposit without removing all of the equipment and extracting the material by chemical treatment. This type of program would be completely prohibitive if the present high production rates are to be maintained. At the present time, all of the equipment is kept in continuous operation more than 99.5% of the time and the major portion of the repair work which is represented by the other 0.5% is of a minor nature which does not require replacement of the major process equipment where the bulk of the uranium is depositied. In addition, such a program would ruin all of the barrier which would be treated

From the foregoing description of the problem, it can be readily seen that the accounting program is a major undertaking--so great that very little progress or research could be started during the initial operating period. During the tremendous, wartime push of starting the plant to produce the material that was to end the war, it was impossible to make the manpower and effort available to set up a good accounting program. If measurements or data were needed that would hold up production, the data were just simply not taken. It was not until April of 1945 that even an engineering type of material balance was made (uranium receipts at K-25 started in September, 1944) and it was not possible to establish a really consistent, well-defined program until early in 1946.

When it became obvious that, in addition to measuring the quantities of gaseous inventory and stocks of uranium held in accessable containers, it would be necessary to estimate the amount of uranium hexafluoride reacting (and disappearing) on plant surfaces, a major research and development program was started on this project. Equipment was removed from the plant, dismantled, and decontaminated for its uranium content. The resulting data showed that the problem had reached staggering proportions, since it was found that the extent of the deposit varied so widely from unit to unit that no estimates could be derived to extrapolate the experimental results to the installed metal surfaces. Statisticians developed new techniques to interpret the data but each time the results indicated that the entire system would have to be dismantled and cleaned up if a real answer to the size of the deposit was required.

During the time since this was realized, a steady program has been carried out which has solved many of the original problems--both in the measurement of the accessible uranium stocks and in the deposits hidden within the plant. A typical list is as follows:

(1) Fundamental studies of uranium chemistry

(2) Fundamental studies of fluorine chemistry

(3) Development of analytical chemical techniques capable of detecting and measuring quantities of uranium combined with other material in concentrations as low as one-half part per million

(4) Studies to improve process system data--plant volumes, surface areas, pump characteristics

(5) Development of absolute pressure measurements accurate to .002%

(6) Development of entirely new statistical methods of interpreting plant data

(7) Improvement of isotope assay machines and methods to accuracies no one thought possible

(8) Development of machines to detect uranium

(9) Further studies of representative plant surfaces

The entire study of the problem has progressed to the point that it is believed that it will be possible to make a complete statement of the uranium inventories on hand. Currently an accounting memorandum is being prepared which will state all that has been found out about the hidden materials in the plant.

The status of Uranium Accountability is presented below for the year 1948. This year was selected since this period is most representative of the present operating controls, and accounting practices.

K-25 Plant Material Balance Experience:

Year 1949 to May 1, 1949

	Uranium Grams	U-235 Grams
Quantity to account for	2,580,818,865	14,420,756
Deficiency	- 95,555	17,109
Percent Accounted for	100.004%	99.881%

December 31, 1947 to December 31, 1948

	Uranium Grams	U-235 Grams
Quantity to account for	2,375,835,049	14,207,415
Deficiency	785,902	91,088
Percent Accounted for	99.967%	99.359%

Beginning of operation to May 1, 1949

	Uranium Grams	U-235 Grams
Quantity to account for	2,614,907,030	18,825,190
Deficiency	6,231,820	340,640
Percent Accounted for	99.762%	98.190%

It should be clearly understood that the quantities of uranium represented by the term "deficiency" does not represent losses, but merely reflects our inability to assign proved values, based on actual measurement, to portions of the uranium currently held in inaccessible plant locations. The previously mentioned work to establish the amount of uranium held in this manner clearly indicates that we can actually account for more than 99% of the U-235 received at the K-25 plant. Research and development work will be continued until 100% of the material can be satisfactorily accounted for by the memorandum type of accounting.

DIVERSION CONTROL OF URANIUM

The program that has been mentioned to this point deals with the evaluation of the quantity of uranium on hand or shipped, compared to the quantity that has been received. This results in data which indicate that some material has been either overlooked during inventory or diverted. Diversion must, therefore, obviously be guarded against.as it may be observed only after the uranium has disappeared. This is accomplished in two ways: One, by assigning to every operator the security of the area in which he works; and, secondly, by physical barriers and guards.

The operator is considered to be a very vital cog in the K-25 security program for the following reasons:

1. Instrument readings would indicate tampering with the equipment

2. He is best qualified to inspect the equipment for possible evidence of diversion

3. He is familiar with the persons normally in his area

Visitors must be cleared for entry by the operating supervisor and in buildings containing high assay uranium, visitors are under the constant escort of an operator. As a result of these precautions, it would be practically impossible for a stranger to enter a major portion of the plant undetected.

In order to gain access to these important areas in the process, it is necessary to cross six physical barriers or pass five guards. For example, in order to get into the top part of the cascade from Oak Ridge it is necessary to pass through the following fence gates:

1. Restricted area (including K-25, X-10, and Y-12)

2. K-25 Plant area

3. Uranium Manufacturing area

4. Area containing the building in the top half of K-25 cascade

5. The middle floor of these buildings

6. The physical piping of the cascade system (see sketch). Each one of these areas require a different badge coding in order to gain entrance.

Added protection is accomplished by guards cruising the area in patrol vehicles.

The K-25 Accountability program then encompasses three major phases:

1. A material balance designed to indicate that protection afforded the material has been successful

2. Research, development, and test programs designed to improve the Material Balance

3. Physical barriers manned by security conscious employees to prevent diversion.

These phases are in addition to the USAEC enforced programs of security checks on individuals.

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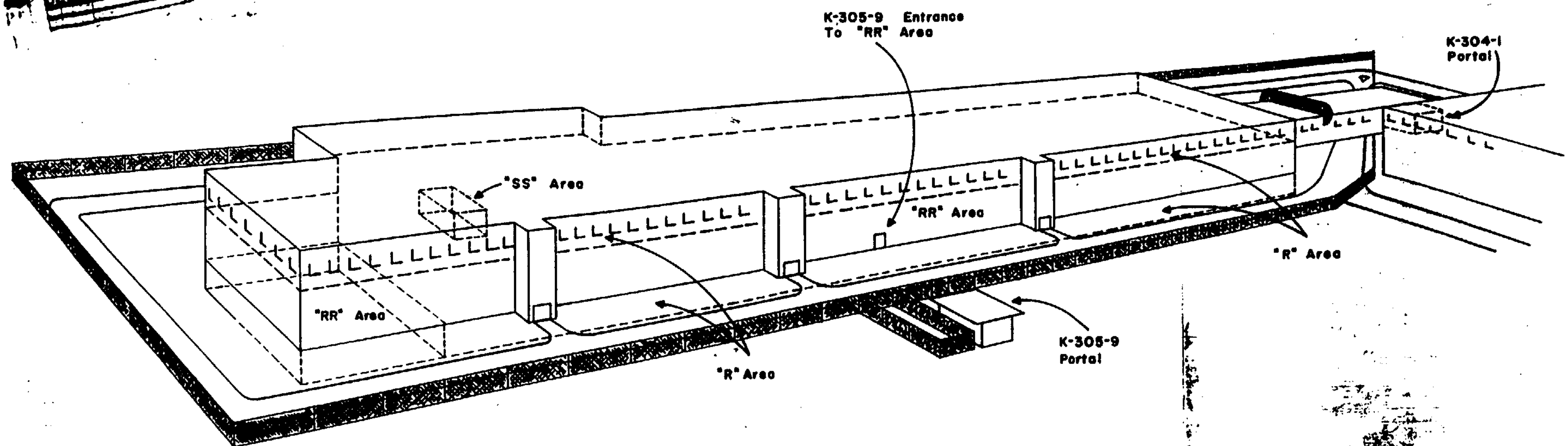

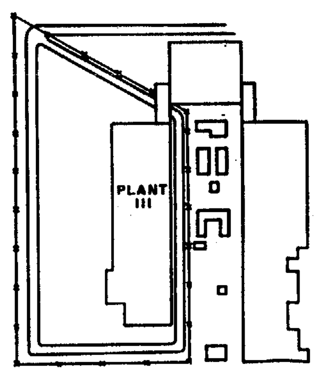

K-25 CASCADE

PLANT III RESTRICTED AREAS

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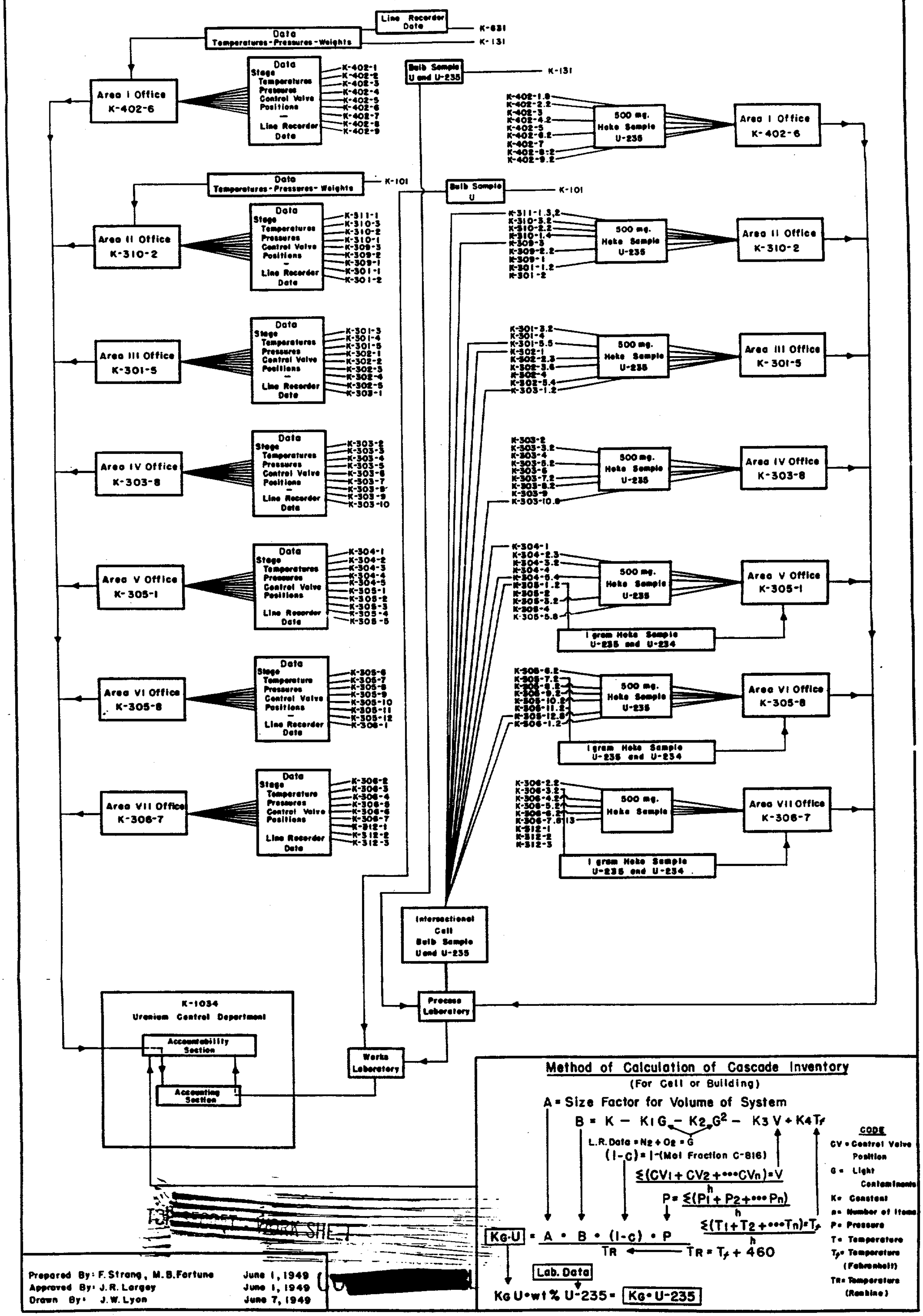
Suggested By: F. Strong
Drawn By: S. B. Thomas
Date: 6-9-49

~~TOP SECRET - WORK SHEET~~ [redacted]

COMPILATION OF DATA AND METHOD OF CALCULATION OF CASCADE INVENTORY



~~TOP SECRET - WORK SHEET~~

Prepared By: F. Strong, M. B. Fortune	June 1, 1949
Approved By: J. R. Largey	June 1, 1949
Drawn By: J. W. Lyon	June 7, 1949

[redacted]

DISTRIBUTION

1. K-25 Site Records (RC)
2. ChemRisk/Shonka Research Associates
3. S. G. Thornton (K-25 EMD)
4. DOE Public Reading Room